TECHNICAL COMMITTEE 3.2
DESIGN AND OPERATION
OF SAFER ROAD INFRASTRUCTURE

2012-2015 ACTIVITY REPORT

CONTENTS

COMMITTEE MEMBERS WHO HAVE CONTRIBUTED TO THE ACTIVITIES

Daniel Aubin, Canada-Quebec
Sybille Birth, Germany
Attila Borso, Hungary
Bystrik Bezak, Slovakia
Carlos Almeida Roque, Portugal
Gerhard Schuwerk, Switzerland
Jindrich Fric, Czech Republik
Jiri Landa, Czech Republik
Lorenzo Domenichini, Italy
Mathieu Holland, France (since Nov 2015)
Paul Schepers, Nederland
Tang Chengcheng, China
Yushi Murashige, Japan
Jan Arsoba, Poland
Abdul Rahman Baharuddin, Malaysia
Xavier Cocu, Belgium
Marion Doerfel, Switzerland
Eric Dumont, France
Juan Carlos Espinosa, Mexico
Jürgen Gerlach, Germany
Paul McCormick, United Kingdom
Peter Saleh, Austria
Kinga Tóthné Temesi, Hungary
Eva Van den Bossche, Belgium
Ali Yero, Niger
Pierre Anelli, France
Uros Brumec, Slovenia
Keith Cota, United States of America
Lise Fournier, Canada - Quebec
Jaakko Klang, Finland
Bernhard Lautner, Austria
Brendan Marsh, Australia
Roberto Llamas, Spain
Mike Greenhalgh, United Kingdom

1 INTRODUCTION

The Activity Report presents an overview of the activities carried out by PIARC Technical Committee TC3.2 on the Design and Operation of Safer Road Infrastructure during the 2012-2015 session.

2 WG 3.2.1 WORK PROGRAMME AND ORGANIZATION

Issue: 3.2.1 Vulnerable Road Users (VRUs)		
Description of the selected strategies	Building from the efforts of TC's C.1 and C.2 of the previous cycle, and the Technical Sheets of the Road Safety manual: • Create guidelines for safer urban and interurban roads with the focus being on the needs of vulnerable road users including pedestrians, young people, cyclist, motorcyclists and others	
Working group leader	Xavier Cocu, Belgium; Marion Doerfel, Switzerland	
Cooperation within PIARC	PIARC Edition Team; TC 3.2.2 and 3.2.3, Task Force Revision of Road Safety Manual	
Cooperation with other organisations	Interaction with different National Committee through members	
Outputs		**Calendar**
Technical reports	Vulnerable Road User matrix Revised Road safety Audit Guidelines and Road safety Inspection Manual Road Safety Manual revision	February 2014, Mid 2014 Thro November 2015
Articles for Routes/Roads		
PIARC international seminars	Zimbabwe Warsaw, Poland New Delhi, India	May 2013 Sep/Oct 2013 Nov 2014
Other events	Sub Group meetings TC meetings Slovenia Belgium Scotland	Every 4-6 months Oct 2012 May 2014 April/May 2015
Sessions at XXV World Road Congress		2-6 November 2015

As a first step the working group (WG) decided to develop a PIARC common agreed definition of VRUs. The WG used the internal resource of its members, reviewed relevant references and consulted with subject experts. The aim was to specifically address the safety issues faced by VRUs in the low and middle income countries (LMICc); For example the WG surveyed the ASANRA group during a joint meeting in Victoria Falls in May 2013.

Having agreed a definition and identifying sub-groups of VRUs' working group reviewed a number of the more recent PIARC guidelines using this new definition. In particular a complete chapter of the "Catalogue of Design Safety Problems and Potential Countermeasures" and the "checklists" provided with the PIARC Road Safety Audit and Road Safety Inspection guidelines were revisited to include additional important issues faced by the various VRUs' sub-groups.

2.1 OUTPUTS

The Working group have developed a Technical Report addressing VRUs safety issues associated with design of the road infrastructure. Initial chapters of this report concentrate on the identification of main types of vulnerable road users and consider several VRU sub-groups. Another is an update of the chapter of the PIARC Catalogue of Design Safety Problems and Potential Countermeasures (2009R07). Another part of the report "RSA & RSI checklists addressing VRUs problems and needs" is an update of the checklists provided with the manuals 2011R01 and 2012R27.

2.1.1 A definition of vulnerable road users

Walking and cycling are transport modes where relatively unprotected road users interact with traffic of high speed and mass. This makes pedestrians and cyclists vulnerable. They suffer the most severe consequences in collisions with other road users because they cannot protect themselves against the speed and mass of the other vehicles.

Compared to cars, powered two-wheelers (PTWs) are less stable, less visible and offer less protection to the driver. All around the world they are involved in a disproportionately high percentage of fatal and serious accidents. This makes mopeds riders and motorcyclists vulnerable.

Similarly, slow and small agriculture vehicle as well as animal drawn vehicles often experience severe consequences in collisions with motorized traffic, due to speed differences and because of their relative un-protection.

Consequently the working group adopted the following definition:

The "vulnerable" road users are those road users who are at great risk because of a lack of enough physical protection or because of relative high speed difference with potential conflicting modes.

Using this definition the working group focussed on four main categories of road users: pedestrians, cyclists, riders of powered two-wheelers, as well as light duty farm vehicles or animal drawn vehicles.

However within these main groups exist a large variety of sub-groups: Children, Elderly, Persons with impaired mobility; Pedal operated cycle, electric (assisted) cycles; Mopeds, Motorcycles, Scooters, Other 3-wheelers and quads; Slow agriculture vehicle without protection, Animal drawn vehicles and their passengers, Street vendors, Animal riders. Each of these groups are described in the technical report.

2.1.2 Design safety problems for VRUs and potential countermeasures

In 2009 PIARC published a "Catalogue of Design Safety Problems and Countermeasures" aimed at developing and emerging countries and countries in transition. The catalogue gives brief information about well-known design errors, suggests a range of methods to overcome these and gives an indication of the comparative countermeasure costs to facilitate prioritization of the work. The catalogue can be used both as a proactive safety tool to ensure the design faults do not arise in the first place, or a reactive safety tool to assist in designing cost-effective countermeasures where problems already exist on the road network.

The sections of these guidelines are further divided into specific problem areas; one section being dedicated to VRUs, more particularly safety problems as faced by pedestrians and cyclists. In view of the definition of VRUs adopted above a review of this section of the catalogue has been conducted by the WG during the 2012 - 2015 cycle.

Using this approach Design/Treatment are described and illustrated. Benefits/Effects are listed (i.e. what VRUs will likely benefit from the measure) and as far as possible Cost and Implementation issues are discussed (cf. example hereafter).

6.03 PROTECTION OF CYCLISTS AT INTERSECTIONS

Problem: Cyclists are often given little consideration at intersections in regard to their vehicular rights and particular vulnerability. This scenario exposes them to motorised traffic that is often travelling at relatively higher speeds. A high percentage of cyclist accidents occur at major/minor priority intersections.

Treatment types & costs		Crash types
T1: A sign-posted alternative cycle route away from the junction	$	• Cyclist-motor vehicle collisions • Cyclist-pedestrian collisions
T2: Modify the layout of the intersection to cater for the cyclists	$	
T3: Signalising the whole intersection Should be used if the volume of cyclists is significant, but not high enough to justify economically a grade separated crossing	$$	**Affected users** • All road users particularly cyclists
T4: Increase vehicle deflection on entry to roundabouts to a reduce approach speeds	$$	
T5: Pre-start in time / area for cyclists	$	

Design/Treatments & Their Benefits

T 1: Alternative provision for the cyclists through separation from motorised traffic

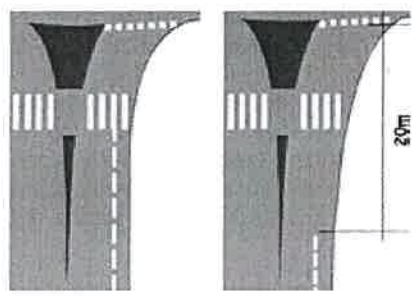
T2: Modify the layout of the intersection to cater for the cyclists

By reducing the number of potential conflict points, as compared to an at-graded junction, the introduction of a roundabout often provides great safety benefits for motorised traffic. However the safety of VRUs, and particularly cyclists, may remain a critical issue if their needs are not appropriately taken into consideration.

Typical conflict points for cyclists at roundabouts are at the entry and the exit.

The safety of cyclists on roundabouts is best ensured on small roundabouts (radius less than 15 m), with a single lane at each entry or exit branch, sufficient path deflection to avoid direct vehicle paths, low radii at entries and exits, and appropriate ring width (around 7 m for single-lane entries).

Cycle lanes in the ring should only be considered for medium-size roundabouts (outside radius between 15 and 22 m), in continuity of existing cycle lanes on either side of the intersection.



Source: CETE Méditerranée

Source: CERTU, "Vélos et giratoires", 2009

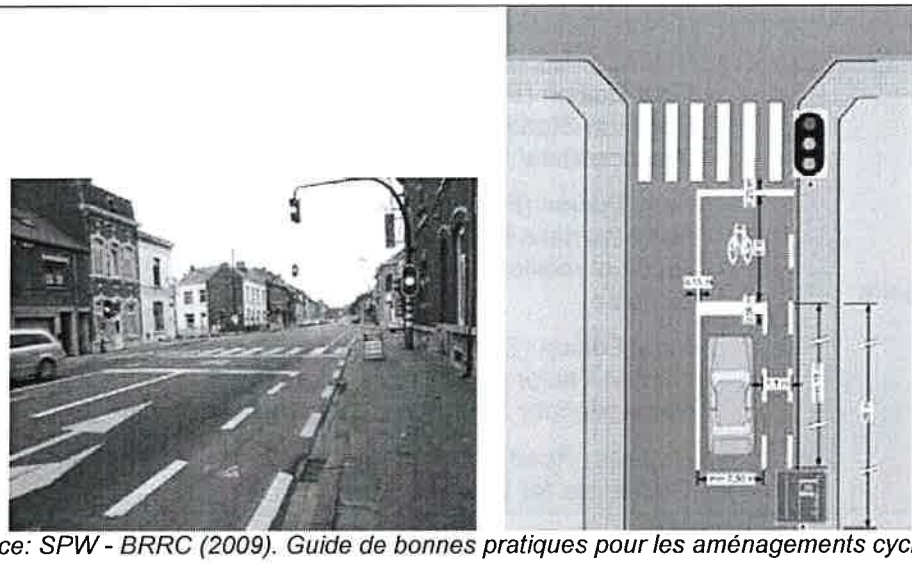
For large roundabouts or complex traffic situations (speed, heavy ground vehicles), the safest approach is to remove the cycle lane/path outside of the roundabout.

T3: Signalise the whole intersection.

T4: Increase vehicle deflection on entry to roundabouts to reduce approach speeds

T5: Pre-start in time / area for cyclists

At traffic lights regulated intersection, the introduction of a pre-start area dedicated to the cyclists may be used to facilitate their left-turning movements and to improve the visibility conditions between cyclists and motorized vehicle drivers. This area should be marked across the entire lane width and be long enough to allow cyclists stopping. The cyclists should be allowed easy access this area, even when motorised vehicles are already stopped in front of the traffic lights; depending on the lane width and the type of cycleway preceding the intersection, the access will be facilitated by a marked cycleway (picture) or simply by cycle pictograms and arrows. Appropriate road signs are also recommended to inform drivers.



Source: SPW - BRRC (2009). Guide de bonnes pratiques pour les aménagements cyclables

Extract of the updated Catalogue of Design Safety Problems and Countermeasures

2.1.3 RSA/RSI checklists addressing VRUs problems and needs

The former road safety technical committees of PIARC produced Guidelines on Road Safety Audits (RSA) and on Road Safety Inspections (RSI). These guidelines have a unique structure in respect of the road characteristics to be checked and analysed and propose detailed checklists to assist both the RSA and RSI procedures.

Parts of these checklists address safety issues faced by vulnerable road users, more particularly safety problems as faced by pedestrians and cyclists. In view of the definition of VRUs adopted above a review of these checklists has also been conducted by the WG during the 2012 - 2015 cycle to better account for the VRUs sub-groups.

3 WG 3.2.2 WORK PROGRAMME AND ORGANIZATION

Issue: 3.2.2 Revision of the Association's Accident Investigation Guidelines	
Description of the selected strategies	Review the Association's existing Accident Investigation Guidelines for engineers and the Human Factors Guidelines to identify knowledge gaps and opportunities to upgrade and update the content.
Working group leader	Daniel Aubin, Canada-Quebec; Sibylle Birth, Germany
Cooperation within PIARC	PIARC Edition Team; TC 3.2.1 and 3.2.3, Task Force Revision of Road Safety Manual
Cooperation with other organisations	Interaction with different National Committee

Outputs		Calendar
Technical reports	Final Edition (English Version): Human Factor in Standards: Audit Results and Best Practices(final title still in decision)	November 2012,
	Final Edition (French Version) : Facteurs humains dans les normes: Résultats de l'audit et meilleures pratiques (final title still in decision)	Beginning 2013
	Final Edition (English and French Version) Human Factor Principles of Spatial Perception for Safer Road Infrastructure	Beginning 2013
	Revised Road Accident Investigation Guidelines for Engineers	Fall 2014, edition till WRC
Articles for Routes/Roads	Human Factor Principles : Spatial Environnement influences on Drivers	Winter 2013
PIARC international seminars	Seminar to be confirmed, Zimbabwe	March 2013
	Seminar to be confirmed, Warsaw, Poland	December 2013
Other events	Group meetings	Every 4-6 months
	Lectures during PIARC Special Session aside 11th Slovenian Road Congress	October 2012
	(Internal Training) Basic principles of Human Factors and accident prevention	January 2013 in Potsdam
	(Internal Training)Reviewing Accident Investigation Methods and Guidelines (to be confirmed)	July 2013 in Czech Republic
	Conference and participation International Baltic Road Conference, Vilnius Lithuania	26-28 August 2013
Sessions at XXV World Road Congress		2-6 November 2015

This working group proposed a completely new approach to investigate accidents and integrate Human Factors in the process. The report will be presented during the Seoul 2015 congress.

In addition, some members were involved in the continuation of work from the last cycle. "Human Factors in Roads Design. Review of Design Standards in Nine Countries" (PIARC 2012R36EN) was translated in French. The old Human Factors Guideline has been revisited and produced in English, French and Spanish (in progress translation).

Finally, leaders from the workgroup were involved in the revision of certain chapters for the new Road Safety Manual (RSM), principally those related to the Man-Road Interface.

As the workload was significant and additional meetings were held to achieve the goal and deliver all the required outputs . .

At the first meeting, members were invited to decide in which subgroup they wished to participate.

Members shared their experience within the RSM Users Group, and will continue to be the link to ensure the chapter related to Human Factors and Accidents will be in accordance with PIARC vision and requirement for references defined in documents in preparation.

A separate writing session was hold between members involved in deliverable from past cycle to define and split the work to produce a final document ready for edition.

A special Human Factors training session was held in Potsdam, Germany in January 2013

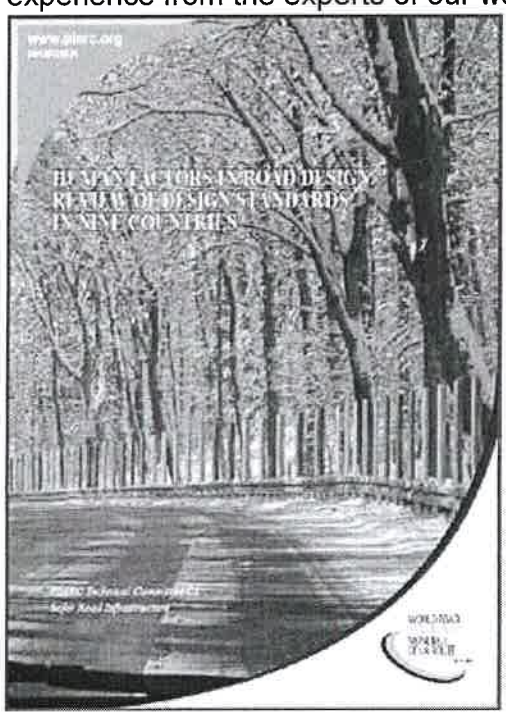
Since the mandate of the workgroup was to integrate Human Factors in the Road Accident Investigation Guideline, it was decided that all members should have the same level of understanding of Human Factors.

During the Road Safety Seminar organized by ASANRA a questionnaire was presented which was designed to assist the workgroup to adapt and include the needs and requirement from Low and Middle Income Countries (LMICs). Results from Countries participating to the seminar are included in the minute of the meeting.

A further special Writing Session held at the University Of Florence in July 2013

During this session the table of contents was fully agreed. All members were assigned their chapter to write and the detailed framework for the new RAI was ready and accepted by members present to the session.

During the Seminar in Poland in October 2013 a special workshop was also held to share experience from the experts of our workgroup with our Polish colleagues.



The workgroup met two days before the Technical Committee Meeting which was being held in Brussels, for a further writing session.

Prior to the Technical committee meeting which is to be held in Glasgow, members of this workgroup will convene for a final writing and revision session.

3.1 OUTPUTS

Human Factors in Roads Design. Review of Design Standards in Nine Countries

In the previous World Road Association cycle from 2008 to 2011, the "IST Checklist 2008" was used to identify the degree to which Human Factors items are explicitly or implicitly addressed in 9 countries´ current national design standards and guidelines for rural distributor roads. The checklist contains about 100 validated Human Factors (HF) criteria especially for spatial perception. Guidelines from these countries were examined:

Portugal, Canada, Australia, Japan, China, Hungary, Czech Republic, France and the Netherlands. The workgroup, principally those from the last cycle, participated to the last and final validation of the English Version of the document "Human Factors in Roads Design. Review of Design Standards in Nine Countries" 2012R36EN.

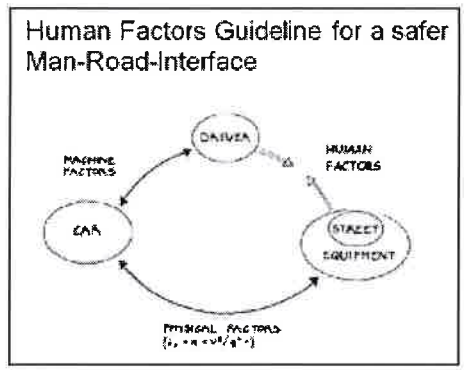
The workgroup finalized the translation of the document into French..

Human Factors Guideline for a safer Man-Road-Interface

The First version of the "Human Factors Guideline (HFG) for Safer Road Infrastructure" was edited by PIARC (2008R18).

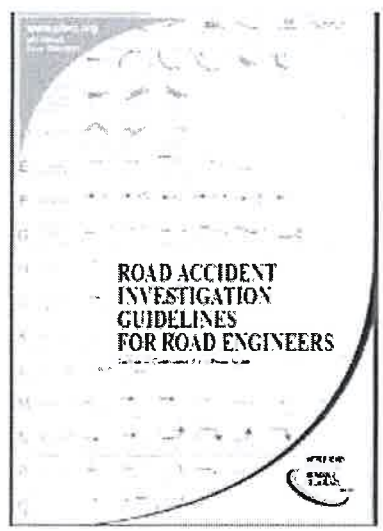
During the preceding cycle, a substantial amount of work was done to prepare the review of design standards required to verify the meaning and the wording of the HFG. This will provide a better understanding for road engineers. In the same time the group decided to revise entirely the guide. In this cycle, members of this workgroup continued their work on the revision of the HFG.

The final edition was prepared and the document will be available entitled: "Human Factors Guideline for a safer Man-Road-Interface". The group helped by collaborators from the last cycle produced the English and French version. The Spanish version is still being prepared



Road Accident Investigation Guideline

The existing guideline for accident investigation by road engineers was published by PIARC in 2007. The workgroup feels strongly that the state of the scientific and technical knowledge regarding the psychological and physiological limits of road users (Human Factors of the Man-Road-Interface) must be brought together and be integrated.



This opens a new approach for using accident data. Traditionally accident data describes human misbehaviour in terms of violation of traffic rules. This results in the primary focus of strengthening countermeasures around education and enforcement of road users. It is also concentrates more on avoiding severe consequences of accidents. Consequently many useful countermeasures leading to forgiving road designs have been developed.

But this practice is still missing the interaction between design features of the road and their effect on the road users. Therefore there is a danger that accident analysis and on-site inspections are will not be able to explain accidents even where the design is to the standards. Very often, in such cases, human mistakes are instigated by misleading and/or unexpected road features.

So the classification of accident types is important but not sufficient in itself. They describe the situation at the end of a chain of incorrect actions and driving manoeuvres. They can provide a hypothesis about the cause or the trigger of the accident for the on-site inspection. The development of effective countermeasures requires the investigation of the accident causes. Specifically it is necessary to identify the real accident trigger – the starting stimulus of a chain of actions which results in an accident.

Within this causes the psychological and physiological threshold values of human abilities play a very important role. It has to be detected by special Human Factors on-site inspection to identify which human abilities and limits had been overstressed or violated, so that the road user had no chance than to make mistakes.

The WG are planning to complete the English version during the meeting in Glasgow. French version will be translated after completion of English.

Participation on the new Road Safety Manual

One of the mandates of this workgroup was to participate in the review and updating of the RSM.. Chapters on accidents in the original version of the RSM were referenced in the original Road Accident Investigation Guideline. Our verification was to be sure all references required in our document still exist in the new RSM.

4 WG 3.2.3 WORK PROGRAMME AND ORGANIZATION

Issue: 3.2.3 Driver distraction and fatigue		
Description of the selected strategies	Identify and document successful strategies for addressing driver distraction and fatigue with the focus on engineering solutions (including road infrastructure, vehicle and road design solutions).	
Working group leader	Brendan Marsh, Australia; Pierre Anelli, France	
Cooperation within PIARC	PIARC Edition Team; TC 3.2.1 and 3.2.2, Task Force Revision of Road Safety Manual	
Cooperation with other organisations	Interaction with different National Committees, REAAA, IRF and AASHTO	
Outputs		**Calendar**
Technical reports	Draft outline structure of the detailed technical report. Principles governing engineering solutions to driver distraction and fatigue together with explanatory text for the Road Safety Manual. Technical report: Relevant existing	November 2012 September 2013 First draft, September 2014 Finalised report,

	literature, the domain of engineering solutions, principles, engineering solutions and case studies across the LIC to HIC spectrum.	June 2015
Articles for Routes/Roads	Engineering Solutions to Driver Distraction and Fatigue – the activities of TC 3.2, Workgroup 3.	June 2013
PIARC international seminars	Zimbabwe and Poland 2013 : Engineering Solutions to Driver Distraction and Fatigue – Workgroup 3 presentation and workshop	April and December 2013
Other events	Group meetings and lectures during PIARC Special Sessions at further future meetings Conference and participation International Baltic Road Conference, Vilnius Lithuania	Every 6 months 26-28 August 2013
Sessions at XXV World Road Congress		2-6 November 2015

After finding that most driver distraction and fatigue material related to improving driver behaviour, the workgroup considered the Safe System approach to road safety and the role of engineering in the case of driver distraction and fatigue. This identified that where engineering achieved a safe system ideal outcome, the fatal and serious injury crash risk associated with driver distraction and fatigue would also be eliminated. It also identified that the human factor work previously undertaken by PIARC could be built upon to promote road design techniques that combat driver distraction and fatigue.

4.1 OUTPUTS

The Workgroup has developed a technical report addressing the road engineering response to driver distraction and fatigue. The chapters consider the different types of driver distraction and fatigue, best practice road safety and the role of engineering, the role of engineering in combating driver distraction and fatigue and examples of driver distraction and fatigue risks and countermeasures.

4.1.1 An examination of the role of road engineering

With most of the literature focusing upon improving driver behaviour so as to encourage avoidance of driver distractions and regular breaks to avoid fatigue, the Workgroup found that road engineering guidance for mitigating driver distraction and fatigue risks is currently limited. The limited nature of the literature probably reflects past approaches to road safety which tended to compartmentalise different types of problems rather than considering a system approach to enable all components of the road system to contribute to their mitigation.

Accordingly, the role of road engineering to mitigate driver distraction and fatigue risks was examined.

Under the Safe System approach, the priority is to prevent fatal and serious injury crash outcomes which is rather different to simply trying to prevent crashes occurring. The approach accepts that crashes are inevitable because humans have physical and cognitive limitations and are fallible – we make mistakes, take risks and sometimes choose to do the wrong thing (e.g. exceed the speed limit). Previous work by the Workgroup

Leader had overlaid the fatal and serious crash prevention priority onto Reason's Swiss Cheese Model, to provide a model for achieving a Safe Road System – see Figure 1.

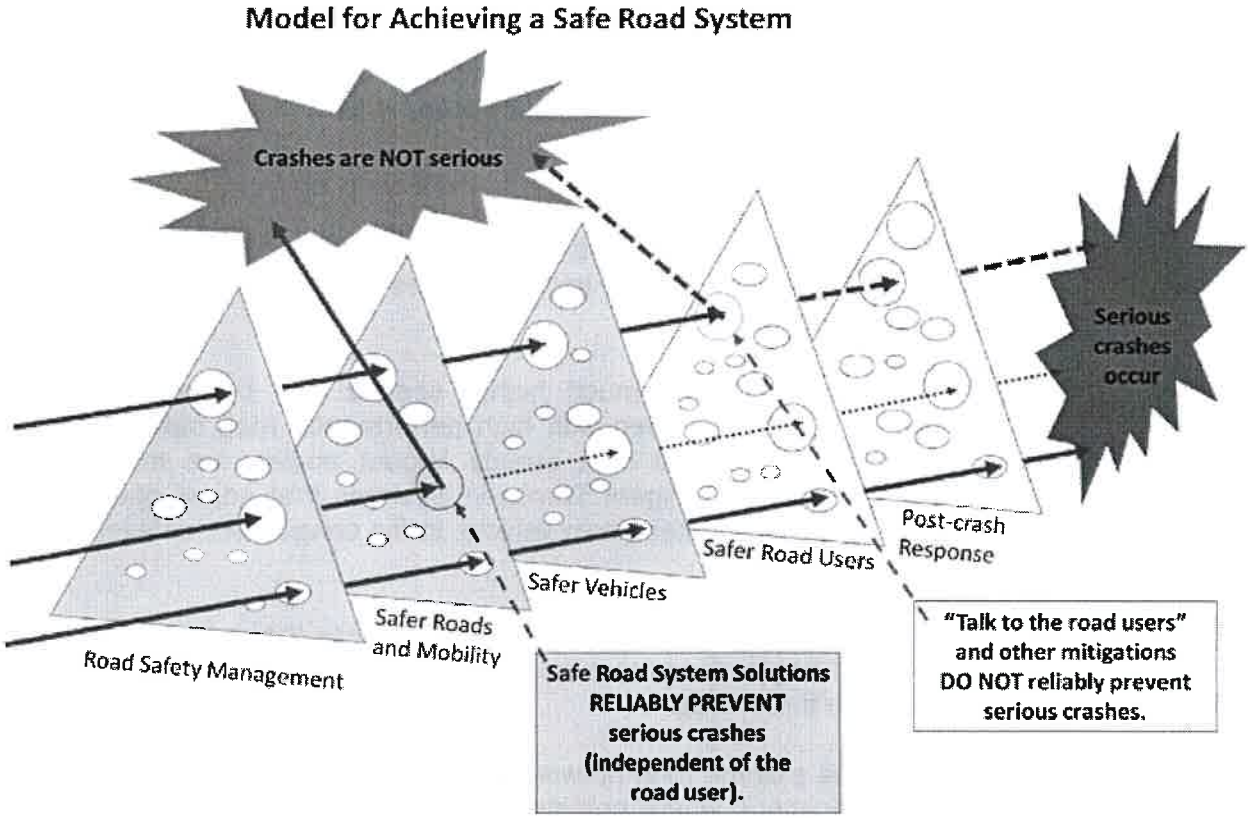


Figure 1: Model for Achieving a Safe Road System

In this model, each pillar of road safety is assumed to have weaknesses that could lead to a fatal and serious crash outcome. The goal is to most effectively block potential fatal and serious injury crash outcomes by leveraging the most feasible alternatives with a system approach.

The model further recognises that Safer Road Users and Post-Crash Response pillars of road safety offer much less reliable alternatives for preventing fatal and serious crash outcomes. While a road system, road and vehicle design is reviewed and checked and reviewed again by experts in the field, drivers are in the heat of the moment making on the spot decisions for which the consequences are born before any review can occur. The post-crash response is after the event and while more rapid and effective medical attention may help to improve healing and survival rates, it is after the event.

In the case of driver distraction and fatigue, aspirational safe system road and vehicle design can prevent fatal and serious crash outcomes nearly independently of driver behaviour. For example, a high performance road safety barrier system will not prevent a crash but will spread the energy dissipation over a longer time period to result in the crash being survivable by all those in a vehicle of reasonable safety standard. For example, traffic calming measures can limit the speed reached by a vehicle and even disable a vehicle seeking to reach speeds where fatal and serious injury outcomes become likely. For example, roundabouts with speed reducing approaches that prevent over-speeding vehicles from even reaching the conflict point can virtually eliminate intersection fatal and serious injury crash outcomes. For example, the future promises advanced technologies

which can assist with the prevention of crashes through cooperative infrastructure and vehicle communications – road authorities should advance their planning for such technologies and start making real time operational information available in real time (such as the next traffic signal change or the current speed limit).

Therefore, at the highest level, the role of road engineering is to target road designs which generally keep crash energies to within the human tolerances for serious injury and death.

The most internationally accepted thresholds are:

- 70km/h for lane departure (head on, run off road and roll over) and rear end crashes
- 50km/h for approximately 90 degree side impact crashes
- 30km/h for unprotected road users.

Where these crash risks are mitigated, much higher speeds can be rather safely accommodated, such as on motorways lined with high performance road safety barrier (located close to the traffic so potential high energy impact angles are minimised) equipped with managed motorways Intelligent Transport Systems that adjust operations when time specific risks arise (e.g. a broken down vehicle, traffic congestion, unfavourable weather, etc).

Any road or network can be quickly assessed for locations where these thresholds are potentially exceeded and road engineering measures can be identified which can generally keep crash energies within the thresholds.

However, there is an extensive existing road network for which treatment in a short period of time is not feasible and locations where complying with the human tolerances would create broader safety or health risks (due to the mobility constraints imposed). Further, as a second order priority, the road design should seek to avoid contributing to driver distraction and fatigue crashes generally.

Therefore, the Workgroup took a closer look at driver distraction and fatigue in order to uncover ways that road engineering can help reduce the risk of either being a crash factor.

4.1.2 An examination of different types of driver distraction

There are a number of sources of driver distraction and ways to categorise driver distraction such as:

- External to the vehicle versus internal to the vehicle, such as other passengers, vehicle comfort controls and electronic devices like mobile phones;
- Matters of the mind such as day dreaming;
- Other messages that over compete critical road signage for the driver's attention, be that roadside advertising or poorly set-out, maintained or designed road signage;
- Scenic landscapes, art forms and structures;
- Unusual events and incidents.

However, to avoid monotony fatigue drivers need to be kept activated and a valid technique for improving driver activation is to arouse the driver's attention such as with a roadside public art work that deliberately captures the attention of the driver.

Further, it was determined that driving a vehicle comprises multiple tasks. A driver cannot check their speed while simultaneously reading a roadside sign. A driver cannot be checking the rear view mirror while scanning the road ahead. In order to collect the information needed to build a picture of the driving situation within the driver's mind, the driver is constantly moving from one driving task to another.

If a driver fails to update an aspect of the driving situation within their mind model, they become more at risk of incorrect decision making.

A novice driver usually finds the driving task challenging because they are not yet efficient and collecting and processing the necessary information.

A respected cognitive scientist, Kahnerman, suggests the idea of conscious versus subconscious operations of the brain. The conscious processing has limited capacity, however, is adept for tackling matters that a person is not accomplished and orchestrating complex tasks such as driving which really comprise a large collection of sub-tasks. By contrast, the subconscious processing capacity seems to only be limited by the information available to it and becomes available to a person as they become accomplished at performing a task.

A novice driver struggles to drive a vehicle because they haven't sufficiently accomplished gear changing, steering and all the other sub-tasks of driving meaning the conscious brain's capacity is being challenged and exceeded because it has few subconscious routines to call upon. By contrast, an accomplished driver can be at risk of monotony fatigue because the majority of the driving task is being performed subconsciously and the conscious brain having extensive spare capacity to an extent that it is getting bored.

Driver distraction is, therefore, not a black and white matter. Whether something beyond the road-scape becomes a distraction depends upon whether it is taking the driver's attention away from the road for so much time that their model of the driving landscape is no longer sufficiently accurate.

Talking on a mobile phone or writing an email or message while driving is particularly dangerous because these activities can require significant and extended focused attention of the driver, compromising their mind's model of the road-scape and ability to make good driving decisions.

A display with numerous changing screens or moving images can prevent a driver from keeping up to date with other driving inputs, which is why many best practice guidelines for Variable Message Signs limit the amount of text used and the number of screens.

A standout public art piece can be a very good thing along an otherwise "boring" road-scape from the perspective of an accomplished driver, however, it becomes a distraction if it competes for the driver's attention with a critical road safety risk, such as an upcoming intersection, because the driver may not even detect the intersection.

So, for a matter to be considered a driver distraction, it must capture the conscious attention of the driver for a sufficient duration such that the driver's model of the road-scape is no longer sufficiently accurate. Also, the relevant duration depends upon the specific driving context as the duration might be negligible in a busy road environment or one unusually affected by an event or roadworks where all drivers need to devote all of their attention to the road. On the other hand on a long and straight lowly trafficked stretch

of remote road with very good visibility ahead and to the sides of the road, the allowable duration before a matter becomes a distraction might extend well into the seconds.

Further scientific research is required to better quantify the allowable duration for a range of road environments.

However, for broad guidance:

- Important road signage should be designed to stand out from the background so that it outcompetes competing messages
- Messages and scenery that compete for the driver's attention should be avoided at "busy" road locations where the full attention of the driver must be on the road.
- Competing messages and scenery may be appropriate where accomplished drivers have substantial surplus conscious attention
- The roadway should be assessed for potential deceptions that might cause a driver to assess that the road ahead is different to reality (e.g. street lighting or the tree line might indicate the road moves in a different direction) or safer than it really is (e.g. geometry or vegetation may obscure an intersection or driveway ahead).

4.1.3 An examination of different types of driver fatigue

A number of classifications of driver fatigue were examined by the Workgroup.

Monotony fatigue is associated with the driver becoming bored due to lack of stimulation. An obvious example is the long and straight road way where the speed limit feels to the driver to be too low. Effectively, monotony fatigue becomes a significant road safety risk on a roadway where the driver does not feel centrifugal forces at the bends, has little decision making being demanded of them and has little to arouse their interest (e.g. an unchanging landscape).

To combat driver fatigue, both sensory and cognitive stimulation should be used to keep the driver optimally activated to maximise their performance of the driving task.

The latest German autobahn design approach is considered to be at the fore front of preventing monotony fatigue because they:

- Seek to prevent straights exceeding 1km in length;
- The geometry is consistently tight so that the driver does feel the centrifugal forces, however, is not at risk of being surprised by a tighter than usual bend;
- Changes in landscape and scenery are sought, such as taking advantage of opportunities to break the road out of a forest to open an expansive view and before too long returning the carriageway to the narrower perspective of the forest;
- Adding public art or advertising messages through boring sections away from the major road safety hazards;
- Preparing drivers for approaching major hazards at least 7s travel time in advance of them.

Further scientific research is required to further advance these developments and provide better guidance for reducing the driver's risk of deactivation and monotony fatigue in any given environment.

Another form of fatigue is related to monotony fatigue, however, is the opposite of it. This is when the driver becomes overwhelmed by the road environment or asked to consciously work very hard resulting in the driver quickly tiring. In general terms, this form of fatigue is less common in accomplished drivers, however, very common in novice drivers, simply due to them needing to expend much more conscious attention as they build their automated driving skills.

However, there types of roads and situations which create the risk of the driver being overwhelmed or tiring very quickly. Types of roads such as hazardous mountain passes on poor quality pavement or tracks can be exceptionally demanding. Where possible, rest areas should be provided that encourage drivers to take a rest. For example, the rest area might be complemented with an exceptional scenic view.

Traffic conditions can also deteriorate due to adverse weather or overwhelming demand. In these cases the operations of the roadway should be adjusted to better suit the prevailing conditions. For example, freeways should be equipped with variable speed limits to enable the speed to be lowered whenever operational risks arise so as to reduce the driver's demand on the conscious brain to reasonable levels.

General tiredness is another form of fatigue. Attractive rest opportunities should be regularly provided along all road systems. This might involve motorway service centres or simpler rest areas, however, where possible, simpler rest areas should coincide with something that is enticing to the driver. Rest areas exposed to the worst of the weather are too often overlooked by drivers.

4.1.4 Summary

Road engineering has a key role to play in mitigating driver distraction and fatigue risks. At the highest level, road engineering measures can be applied to prevent fatal and serious injury crash outcomes even with the presence of driver distraction and fatigue.

Road engineering can also reduce the risk of driver distraction and fatigue crashes occurring by designing roadways that manage the activation levels of drivers, keep possible distractions away from demanding road environments and provide attractive opportunities for regular driving breaks to be taken.

BIBLIOGRAPHICAL REFERENCES

- BIBLIOGRAPHICAL REFERENCES
- Catalogue of design safety problems and potential countermeasures. PIARC Reference 2009/R07.
- Road safety audit guideline for safety checks of new road projects. PIARC Reference 2011/R01.
- Road safety inspection guideline for safety checks of existing roads. PIARC Reference 2012/R27EN
- Draft PIARC Human Factor Guideline
- Kahnerman, Thinking Fast and Slow, 2011
- Marsh, Applying the New Road Safety Paradigm in Major Projects, Routes Roads 2013 No 359, page 71.